

Construction Specification 432—Structure Concrete & Steel Reinforcement

1. Scope

The work shall consist of furnishing, forming, placing, finishing, and curing Portland cement concrete and furnishing and placing steel reinforcement as required to build the structures shown on the drawings.

2. Materials

(Note: Material specifications listed in the State of Maine Department of Transportation Standard and Specifications not listed in this specification can be used upon approval of the NRCS engineer)

- A. **Portland cement** shall be Type II or Type IIA as specified in ASTM C 150 or as otherwise specified on the plans. Fly ash used a partial substitution of Portland cement shall conform to the requirements of ASTM C 618, Class C or F. Blast furnace slag used as a partial substitution of Portland cement shall conform to ASTM Standard C 989 for ground granulated blast-furnace slag.
- B. **Water used in mixing and curing concrete** shall be clean and free from injurious amounts of oil, salt, acid, alkali, algae, organic matter, or other deleterious substances.
- C. **Aggregates** shall conform to the requirements of ASTM C 33 for fine and coarse aggregate for concrete. Aggregates must be clean, hard, strong, and durable particles free of absorbed chemicals, clay coatings, organic materials, trash, and clay or soil balls. Aggregates are to be handled in a way that minimizes segregation. The maximum size of aggregate particles should not exceed:
 - a. 1/5 the narrowest dimension of the member
 - b. 3/4 the clear spacing between reinforcing bars and between reinforcing bars and forms
 - c. 1/3 the depth of the slab
- D. **Fiber Reinforcing** may be used when approved by engineer. Fiber to be added to concrete during batching at a rate of 0.1% to 0.2% by volume.
- E. **Steel bar reinforcement** Reinforcing bars shall be Grade 60 unless otherwise specified on the drawings or approved by the engineer. Reinforcing steel shall conform to ASTM A 614 or ASTM A 996. Dowels shall be plain round bars conforming to the same specifications for deformed steel bars. Epoxy coated bars shall conform to the requirements of ASTM A 775. Welded steel wire fabric reinforcement shall conform to ASTM A 185. Gauges, spacing and arrangement of wires shall be as defined in ACI Standard 315. When placed, reinforcing bars shall be free from loose, flakey rust, mill scale, oil, grease, or paint.
- F. **Chemical Admixtures**
 - a. **Air-entraining admixtures** shall conform to the requirements of ASTM C 260. If air-entraining cement is used, any additional air-entraining admixture shall be of the same type as that in the cement.

- b. **Water reducing and/or retarding admixtures** shall conform to the requirements of ASTM C 494, Types A, B, D, F or G.
 - c. **Plasticizing admixtures** or plasticizing and retarding admixtures shall conform to the requirements of ASTM C 494 Types F or G, or ASTM C 1017 as applicable.
 - d. **Accelerating and water-reducing and accelerating admixtures** shall be noncorrosive and conform to the requirements of ASTM C 494, Types C and E.
 - e. **Other admixtures** such as accelerators or retarders may be used with the approval of the engineer.
- G. **Curing compound** shall conform to the requirements of ASTM C 309 or ASTM C 1315. Curing compounds shall be delivered to the site in the original container. The compound shall be stored on site to prevent damage to the container or freezing.
- H. **Preformed expansion joint filler** shall conform to the requirements of ASTM D 1752, Type I, Type II or, Type III, unless bituminous type is specified. Bituminous type preformed expansion joint filler shall conform to the requirements of ASTM D 994.
- I. **Waterstops** shall conform to the requirements of NRCS, NEH Part 642 Material Specifications 537, Nonmetallic Waterstops, and 538, Metal Waterstops, for the specified kinds or US Army Corps of Engineers Specification CRD c-572.

3. Class of concrete

Concrete shall have a minimum design strength of 3500 psi at 28 days, unless otherwise specified. Fly ash may be used as a partial substitution for Portland cement in an amount of no more than 25 percent (by weight) of the cement in the concrete mix, unless otherwise specified. The contractor is responsible for design and proportioning of the concrete mix to attain the specified compressive strength.

4. Air content and consistency

Unless otherwise specified the air content (by volume) shall be 5 to 7 percent of the volume of the concrete at the time of placement. Air entrainment admixtures can be added to meet the air content requirements.

Unless otherwise specified, the slump shall be 3 to 5 inches. High range, water reducing agents (plasticizers) may be used to increase workability, reduce water content, and control concrete temperature in hot weather. The maximum slump after adding high range water reducing agents (plasticizers) shall be 7.5 inches. The slump shall be 3 inches or less prior to the addition of any water reducing agents. When specified, directed, or approved by the engineer, a water-reducing, set-retarding, or other admixture shall be used. Any admixtures used shall meet the requirements in Section 2 unless otherwise approved by the engineer.

5. Mixers and mixing

Concrete shall be uniform and thoroughly mixed when delivered to the work site. The proportions of the aggregates shall be such as to produce a concrete mixture that will work readily into corners and angles of the forms and around reinforcement when consolidated, but not segregated or exude free water during consolidation. Variations in slump of more than 1 inch within a batch are considered evidence of inadequate mixing

and shall be corrected by increasing mixing time or other acceptable alternative.

No mixing water in excess of the amount called for by the job mix shall be added to the concrete during mixing or hauling or after arrival at the delivery point.

6. Forms

Forms shall be of wood, plywood, steel, or other approved material and shall be mortar tight. The forms and associated falsework shall be substantial and unyielding and shall be constructed so that the finished concrete will conform to the specified dimensions and contours. Form surfaces shall be smooth and free from holes, dents, sags, or other irregularities. Forms shall be coated with a nonstaining form release agent before being set into place.

For liquid-tight structures metal ties or anchorages within the forms shall be equipped with cones, she-bolts or other devices that permit their removal to a depth of at least 1 inch (unless otherwise specified) without injury to the concrete. Ties designed to break off below the surface of the concrete shall not be used without cones. If approved fiberglass or plastic form ties are used, the tie ends shall be cut flush with the finish concrete and ground smooth.

For structures which are not required to be liquid-tight, form ties shall be removed flush with or below the concrete surface.

All edges that will be exposed to view when the structure is completed shall be chamfered, unless finished with molding tools.

7. Steel reinforcement

Before steel is placed, the surface of the bars shall be cleaned to remove loose rust, mill scale, oil, grease, or other foreign substances. Bars of specified size shall be accurately placed as shown on the drawings and shall be securely tied in position to prevent its displacement during the placement of concrete. If not shown on the drawings, the minimum bar cover for concrete cast in forms or exposed to the weather shall be 1.5 inches (2 inches for #6 bars or larger) The minimum bar cover for concrete cast against earth shall be 3 inches.

Tack welding of bars will not be permitted. Metal chairs, metal hangers, metal spacers, plastic chairs, and concrete chairs may be used to support the reinforcement. Metal hangers, spacers and ties shall be placed in such a manner that they will not be exposed in the finished concrete surface. The legs of metal chairs that may be exposed at the lower face of slabs or beams shall be galvanized. Precast concrete chairs shall be manufactured of the same class of concrete as that specified for the structure. Precast concrete chairs shall be moist at the time concrete is placed. The chairs will be spaced as needed to prevent displacement of the steel. The need and method of supporting the reinforcement will be determined by the engineer and/or inspector or as shown on the drawings.

Reinforcement shall be cut and bent in compliance with the requirements of the American Concrete Institute (ACI) Standard 315. Bars with kinks, cracks or improper bends will be rejected. When not specified in the steel schedule, bars may be cut and bent in the field. Bars shall not be heat bent.

Unless otherwise specified on the drawings, splices of reinforcing bars shall be in accordance with the ACI Building Code Requirements for Reinforced Concrete (ACI 318). Minimum splice lengths shall be as shown below:

Minimum Lap Splice Length (inches)									
Bar Type	Bar Size (mm)								
	#3(10)	#4(13)	#5(16)	#6(19)	#7(22)	#8(25)	9#(29)	#10(32)	#11(36)
Plain	17	22	28	33	48	55	62	68	76
Epoxy Coated	20	27	33	39	58	66	74	83	91

Splice lengths as per ACI 318-05 based on 3000 psi concrete.

Welded wire fabric shall be spliced by overlapping one full mesh of adjacent sections plus 2 inches and securing the pieces together with wire ties.

Steel reinforcement stored at the site of the work shall be stored above the ground surface on platforms, skids or other supports and shall be protected from mechanical injury and corrosion.

Reinforcement material (such as fiber mesh) other than steel bars or welded wire fabric may be used with the approval of the engineer.

8. Preparation of forms and subgrade

Prior to placement of concrete, the forms and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings and the temperature of all surfaces to be in contact with the new concrete shall be not be less than 40 degrees Fahrenheit. Any oil on the reinforcing steel or other surfaces required to be bonded to the concrete shall be removed. Rock surfaces shall be cleaned by air-water cutting, wet sandblasting, or wire brush scrubbing, as necessary, and shall be wetted immediately before placement of concrete. The earth surface shall be firm and damp. Placement of concrete on mud, dried earth, or uncompacted fill or frozen subgrade is not permitted.

Items to be embedded in the concrete shall be positioned accurately and anchored firmly.

Weepholes in walls or slabs shall be formed with nonferrous material.

9. Conveying

Concrete shall be delivered to the site and discharged into the forms within 1-1/2 hours after the introduction of the cement to the aggregates. In hot weather or under conditions contributing to quick stiffening of the concrete, the time between the introduction of the cement to the aggregates and discharge shall not exceed 45 minutes unless an approved set-retarding admixture is used or the mix remains workable and the temperature does not exceed the requirements stated in Section 20. In any case, concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods that prevent segregation of the aggregates and assure no loss of mortar occurs.

10. Placing

Concrete shall not be placed until the subgrade, forms, steel reinforcement, and embedded items have been inspected and approved. The engineer will determine any required testing needed for the placement of the specified concrete. No concrete shall be placed except in the presence of the engineer or with permission from the engineer. The contractor shall give reasonable notice to the engineer each time concrete is to be placed. Such notice shall provide sufficient time for the engineer to inspect the subgrade, forms, steel reinforcement, and other preparations for compliance with the specifications. Deficiencies are to be corrected before concrete is delivered for placing. The engineer can delegate any or all duties to other qualified personnel.

The concrete shall be deposited as closely as possible to its final position in the forms. It shall be worked into the corners and angles of the forms and around all reinforcement and embedded items in a manner to prevent segregation of aggregates or excessive laitance. Formed concrete shall be placed in horizontal layers not more than 20 inches deep. When a superplasticizer is used the horizontal layer can be increased to 5 ft. deep. Slab concrete shall be placed to design thickness in one continuous layer. Concrete shall not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation. When a superplasticizer used, the concrete shall not be allowed to drop more than 10 feet. Hoppers and chutes, pipes, or "elephant trunks" shall be used as necessary to prevent segregation and the splashing of mortar on the forms and reinforcing steel above the layer being placed.

Immediately after the concrete is placed in the forms, it shall be consolidated by spading, hand tamping, or vibration as necessary to ensure a smooth surface and dense concrete. Each layer shall be consolidated to ensure monolithic bond with the preceding layer. The use of vibrators shall not be used to transport concrete in the forms, slabs, or conveying equipment. Vibration shall not be applied directly to the reinforcement steel or the forms. If the surface of a layer of concrete in place sets to the degree that it will not flow and merge with the succeeding layer when spaded or vibrated, the contractor shall discontinue placing concrete and shall make a construction joint according to the procedure specified in section 11.

If placing is discontinued when an incomplete horizontal layer is in place, the unfinished end of the layer shall be formed by a vertical bulkhead.

11. Construction joints

Construction joints shall be made at the locations shown on the drawings. If construction joints are needed that are not shown on the drawings, they shall be placed in locations approved by the engineer.

Where a feather edge would be produced at a construction joint, as in the top surface of a sloping wall, an insert form shall be used so that the resulting edge thickness on either side of the joint is not less than 6 inches.

In walls and columns, as each lift is completed, the top surface shall be immediately and carefully protected from any condition that might adversely affect the hardening of the concrete.

Steel tying and form construction adjacent to concrete in place shall not be started until the concrete has cured at least 12 hours. Before new concrete is deposited on or

against concrete that has hardened, the forms shall be retightened. New concrete shall not be placed until the hardened concrete has cured at least 12 hours.

The surface of construction joints shall be cleaned of all unsatisfactory concrete or other foreign materials by means approved by the engineer. The surface shall be kept moist for at least 1 hour before the new concrete is placed.

12. Expansion/isolation and contraction/control joints

The types and locations of expansion and contraction joints shall be made only at locations shown on the drawings unless otherwise directed by the engineer.

Exposed concrete edges at expansion and contraction joints shall be carefully tooled or chamfered, and the joints shall be free of mortar and concrete. Contraction joints can be constructed using saw cuts to a depth of approximately $\frac{1}{4}$ of the total thickness between 4 to 12 hours from when the concrete is placed.

Preformed expansion joint filler shall be held firmly in the correct position as the concrete is placed. Joint filler shall be left exposed for its full length with clean and true edges.

When open joints are specified, they shall be constructed by the insertion and subsequent removal of a wooden strip, metal plate, or other suitable template in such a manner that the corners of the concrete are not chipped or broken. The edges of open joints shall be finished with an edging tool before the joint strips are removed.

13. Waterstops

Waterstops shall be held firmly in the correct position as the concrete is placed. Joints in metal waterstops shall be soldered, brazed, or welded. If specified by the engineer joints in rubber or plastic waterstops shall be cemented, welded, or vulcanized as recommended by the manufacturer.

14. Removal of forms

Forms shall be removed in such a way as to prevent damage to the concrete. Supports shall be removed in a manner that permits the concrete to take the stresses of its own weight uniformly and gradually. The minimum period from completion of the concrete placement to the removal of the forms shall be based on either strength tests or cumulative times.

- **Strength tests** – The strength of the in place concrete is determined by testing concrete cylinders specifically cast for this purpose and cured adjacent to the member in accordance with the ASTM C 31 method for determining removal time. Unless otherwise specified, forms supporting the weight of the concrete member may be removed after the concrete strength is 70 percent of that specified for the class of concrete.
- **Cumulative time** – The total accumulative time, not necessarily continuous, that the air adjacent to the concrete is above 50 degrees Fahrenheit and the specific concrete curing has occurred concurrently will be determined. Forms may be removed after the total accumulation time shown below.

Accumulation form removal times

Forms		Time ^{1/}
Sides of slabs or beams		12 hours
Undersides of slabs or beams	Clear span	<u>2/</u>
	< 10 ft	4 days
	10 - 20 ft	7 days
	> 20 ft	14 days
Sides of wall or columns	Height	<u>3/</u> <u>4/</u>
	< 10 ft	12 hours
	< 20 ft	24 hours
	> 20 ft	72 hours

1/ Table values apply to normal concrete. Values for concrete that contains cements or admixtures that significantly

retard or accelerate strength gain will be determined by the engineer and based on actual design mix data.

2/ Values apply to members designed to support significant superimposed loads.

Values for members designed for

only self weight when placed in service shall be 50 percent greater.

3/ Values apply to members not subject to significant horizontal loads. Additional time or rebracing is needed for

members subject to significant wind or other horizontal loads.

4/ Subsequent higher lifts may be placed after 12 hours.

15. Finishing formed surfaces

Immediately after the forms are removed:

- a. All fins and irregular projections shall be removed from exposed surfaces.
- b. The holes produced on all surfaces by the removal of form ties, cone-bolts, and she-bolts shall be cleaned, wetted, and filled with a dry-pack mortar. The mortar will consist of one part Portland cement, three parts sand that will pass a No. 16 sieve, and just sufficient water to produce a consistency such that the filling is at the point of becoming rubbery when the material is solidly packed. Other proprietary patching material shall be appropriate for the type of repair, used with manufacturer's recommended limits, and applied according to the manufacturer's recommendations.

16. Finishing unformed surfaces

All exposed surfaces of the concrete shall be accurately screeded to grade and then float finished, unless specified otherwise.

Excessive floating or troweling of surfaces while the concrete is soft is not permitted.

Adding dry cement or water to the surface of the screeded concrete to expedite finishing is not allowed.

Joints and edges on unformed surfaces that will be exposed to view shall be chamfered or finished with molding tools.

17. Curing

Concrete shall be prevented from drying for a curing period of at least 7 days after it is placed. All concrete and its surfaces shall be kept from freezing during the curing period. The required curing period may be reduced if a mix is used that will accelerate the curing time. For accelerated mixes the curing time shall not be less than 3 days. Any accelerated mixes and reduced curing times must be approved by the engineer. Exposed surfaces shall be kept continuously moist for the entire period, or until curing compound is applied as specified below. Moisture shall be maintained by sprinkling, flooding, or fog spraying, or by covering with continuously moistened canvas, cloth mats, straw, sand, or other approved material. Wood forms left in place during the curing period shall be kept continuously wet. A formed surface shall be thoroughly wetted immediately after forms are removed and shall be kept wet until patching and repairs are completed. Water or covering shall be applied in such a way that the concrete surface is not eroded or otherwise damaged.

Concrete, except at construction joints, may be coated with the approved curing compound instead of continued application of moisture, except as otherwise specified. The compound shall be sprayed on the moist concrete surface as soon as free water has disappeared, but shall not be applied to any surface until patching, repairs, and finishing of that surface are completed. The compound shall be applied at a uniform rate of not less than 1 gallon per 175 square feet of surface and shall form a continuous adherent membrane over the entire surface. Curing compound shall be thoroughly mixed before applying and continuously agitated during application. Curing compound shall not be applied to a surface requiring bond to subsequently placed concrete, such as construction joints, shear plates, reinforcing steel, and other embedded items. If the membrane is damaged during the curing period, the damaged area shall be resprayed at the rate of application specified above. Any surface covered by the membrane shall not be trafficked unless protected from wear.

18. Removal and replacement or repair

When concrete is honeycombed, damaged, or otherwise defective, the contractor shall remove and replace the structure or structural member containing the defective concrete or, where feasible, correct or repair the defective parts. The engineer determines the required extent of removal, replacement, or repair. Before starting repair work, the contractor shall obtain the engineer's approval of the plan for repairs. The final repair work will result in at least the same structural strength of the original design.

19. Concreting in cold weather

Concrete shall not be mixed nor placed when the daily minimum atmospheric temperature is less than 40 degrees Fahrenheit unless facilities are provided to prevent the concrete from freezing. The use of accelerators or water reducing admixtures will be approved by the engineer. Concrete shall not be placed on frozen surfaces or forms. The temperature of the concrete at the time of placing shall be within the placement temperature range shown below, unless otherwise specified.

Least dimension of section, inches	Placement temperature, °F
Less than 12	55 – 75
12 to 36	50 – 70
36 to 72	45 – 65
Greater than 72	40 – 60

The minimum temperature of the concrete for the first 72 hours after placement shall not be less than the minimum temperature shown above. If the minimum temperature requirements are not met and the concrete did not freeze, the protection time will be extended a period equal to twice the number of hours the temperature was below the minimum temperature. At the end of the protection period, the concrete shall be allowed to cool gradually. The maximum decrease at the concrete surface in a 24-hour period shall not exceed 40 °F. The contractor shall supply a cold weather concrete plan and monitoring plan to be approved by the engineer.

20. Concreting in hot weather

The contractor shall apply effective means to maintain the temperature of the concrete below 90 degrees Fahrenheit during mixing, conveying, and placing.

21. Measurement and payment

For items of work for which specific unit prices are established in the contract, concrete is measured to the neat lines shown on the drawings and the volume of concrete is computed to the nearest 0.1 cubic yard. Measurement of concrete placed against the sides of an excavation without using intervening forms is made only to the neatness or pay limits shown on the drawings. No deduction in volume is made for chamfers, rounded or beveled edges, or for any void or embedded item that is less than 5 cubic feet in volume.

Payment for each item of structure concrete is made at the contract unit price or the contract lump sum; whichever is applicable for that item. Such payment constitutes full compensation for all labor, material, equipment, transportation, tools, forms, falsework, bracing, and all other items necessary and incidental to the completion of the work except items listed for payment elsewhere in the contract. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 22 of this specification.

22. Items of work and construction details